# Distributed Energy Resources Integration Research Program

***Integration of RES and DER Conference***
***European Commission – Research Directorate***
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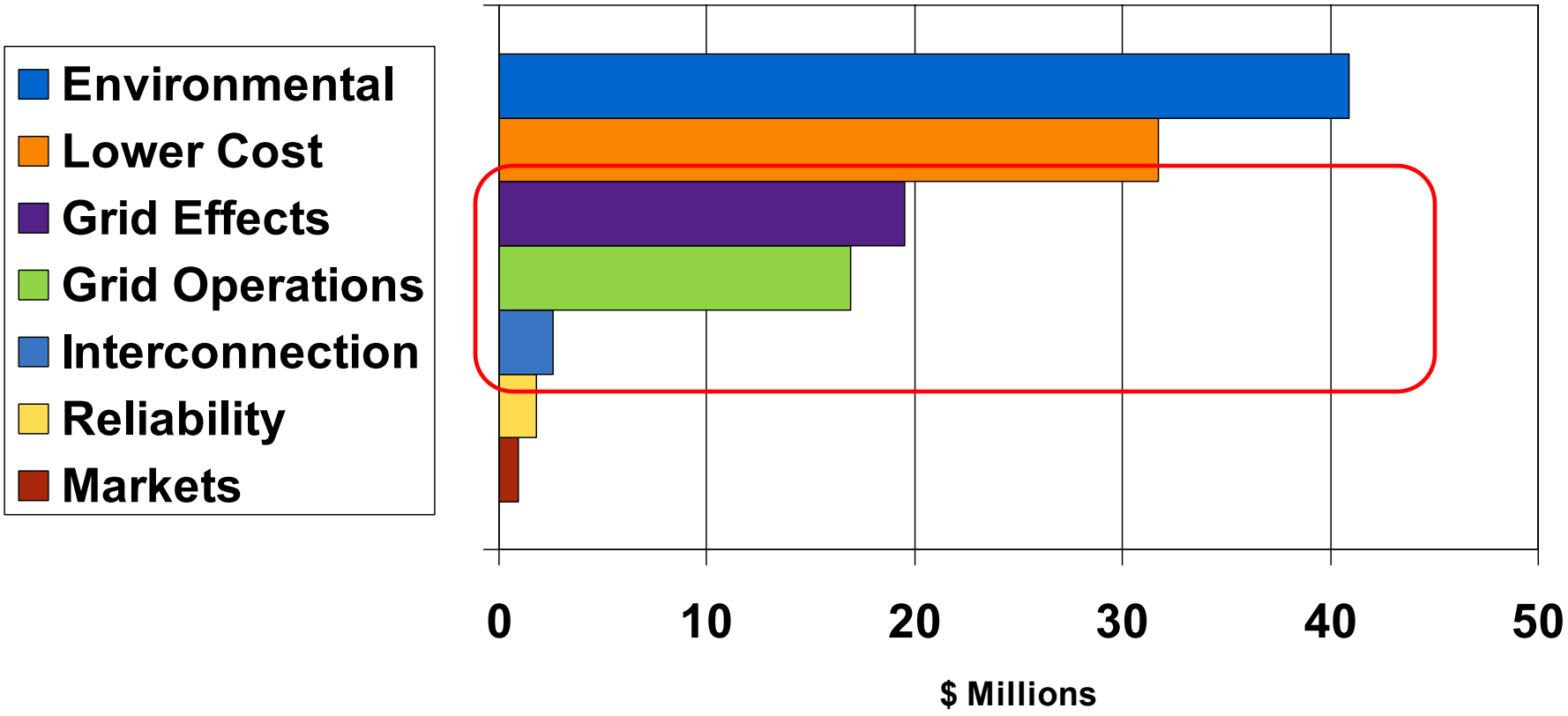
# PIER DG Portfolio

**114 projects are DG related and total $114M out of over $336M in total PIER-funded R&D.**




**35% of portfolio focused on integrating DG into the power system and markets.**

# DER Integration R&D Program Focus

**DER Integration program focuses on systems research linking technology and policy.**

**What RD&D is needed in order to enable DER to be a significant resource in California's power system?**

### Interconnection

Can a substantial amount of DER be interconnected in both radial and networked distribution systems?

### Grid Effects

Would a high penetration of DER have adverse impacts and/or positive effects on the T&D system?

### Market Integration

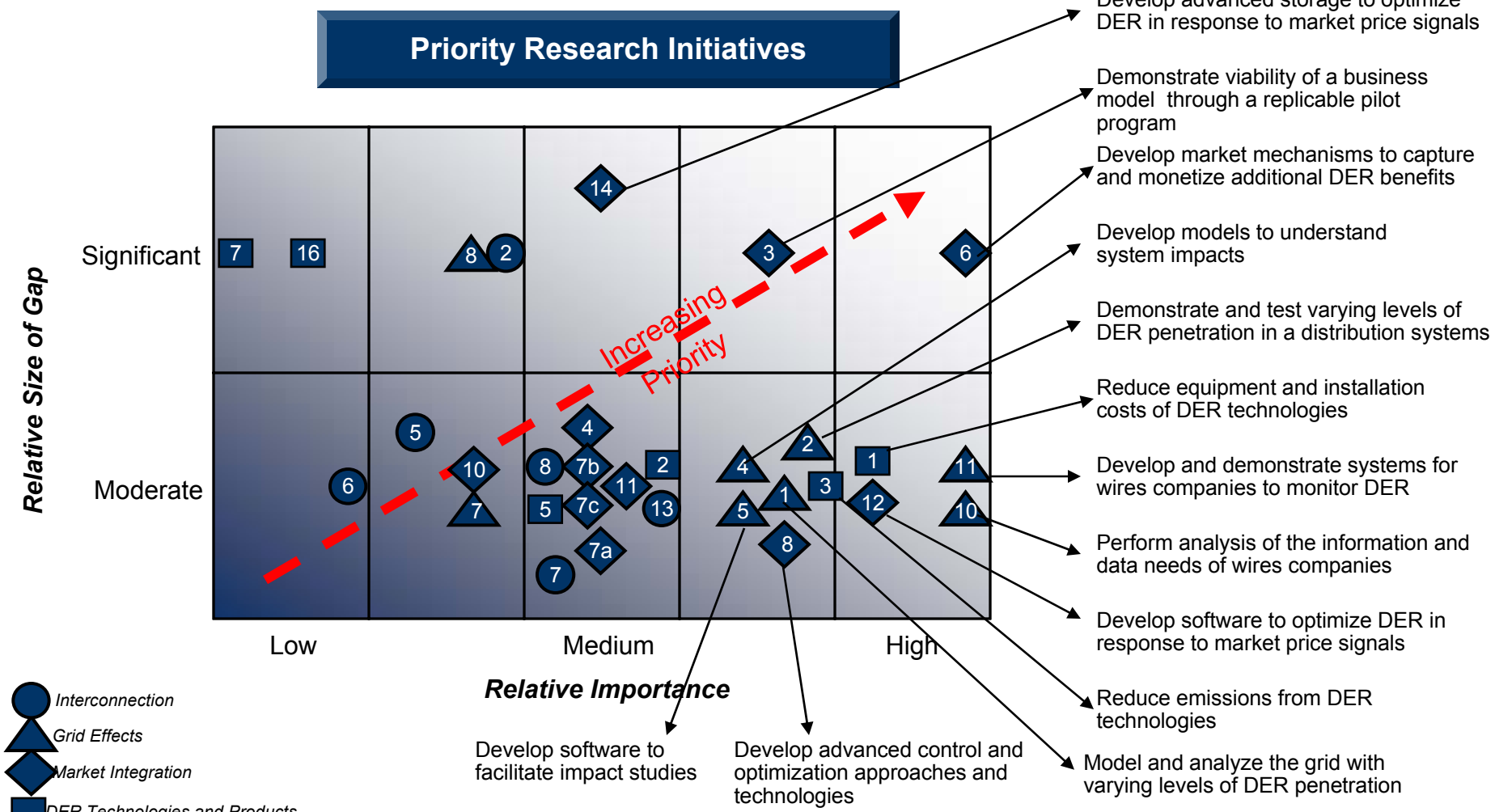
Can DER access robust markets or be exposed to price signals that will maximize benefits to customers and the power system?

## Benefits of Doing Research

- **CPUC adopts interconnection rules as revised**
- **New research focus on grid and environmental benefits will inform CEC and CPUC policy**
- **Power system paradigm shifted to decentralized structure creating benefits such as:**
  - **More Reliability and Higher Quality ➔ Greater flexibility and resiliency to disturbances through optimal control and operation of DER and power system**
  - **More Efficient, Cheaper, Cleaner ➔ Reduction of T&D losses and congestion, and cleaner emissions and better use of fuel through CHP**
  - **Quicker System Expansion ➔ Modularity and scalability of DER enables quicker, more flexible increases in system capacity and to address regional specific problems**

# High Priority Initiatives

**There are 13 research initiatives that are high priority based on the relative gap and importance that are appropriate for public funding support.**

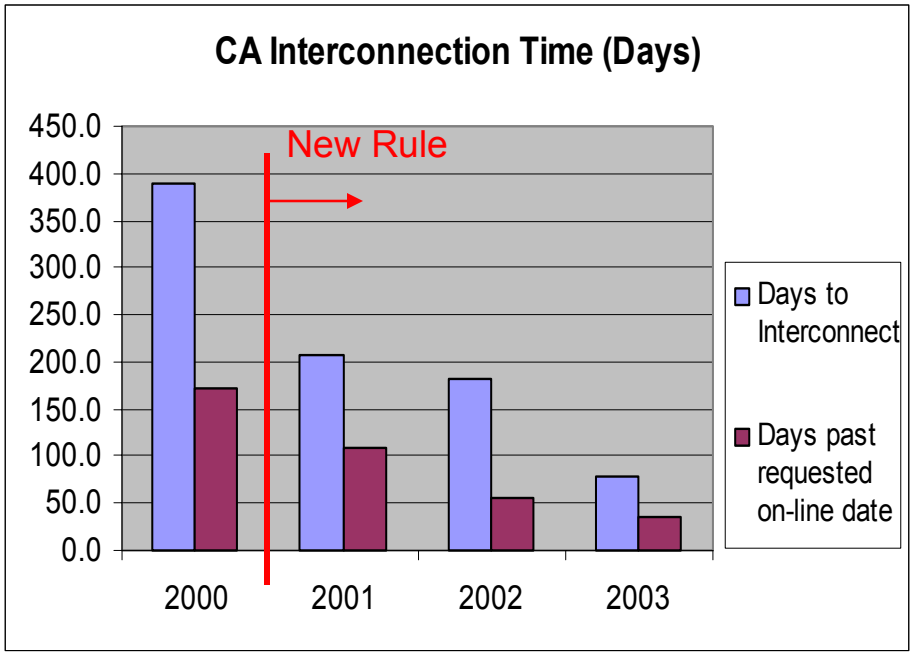


# Current Projects

- **Initial program priority was interconnection and then grid effects.**
- **New priorities are understanding market and regulatory issues affecting DER and reducing interconnection/equipment costs.**

- **Utility System Integration Testing**
  - Distributed Utility Integration Test (DUIT)
  - Laboratory testing of varying levels of DER in distribution systems
  - $5.0M with DOE $2.2M leverage
- **Interconnection Device and Utility System Testing**
  - National Renewable Energy Lab (NREL)
  - Developing interconnection devices
  - Understanding voltage regulation impacts
  - Innovative rate design
  - $1.6M
- **T&D System Modeling Tool**
  - New Power Technologies
  - Developing integrated T&D modeling tools to assess locational benefits of DER
  - $6.0M
- **Microgrid Testing**
  - Consortium for Electric Reliability Technology Solutions (CERTs)
  - Microgrid concept development and laboratory testing
  - $4.5M with DOE $2.8M leverage
- **Interconnection Rules**
  - Reflective Energies
  - Interconnection rule
  - Interconnection monitoring
  - Interconnection guidebook
  - IEEE 1547 coordination
  - $2.0M

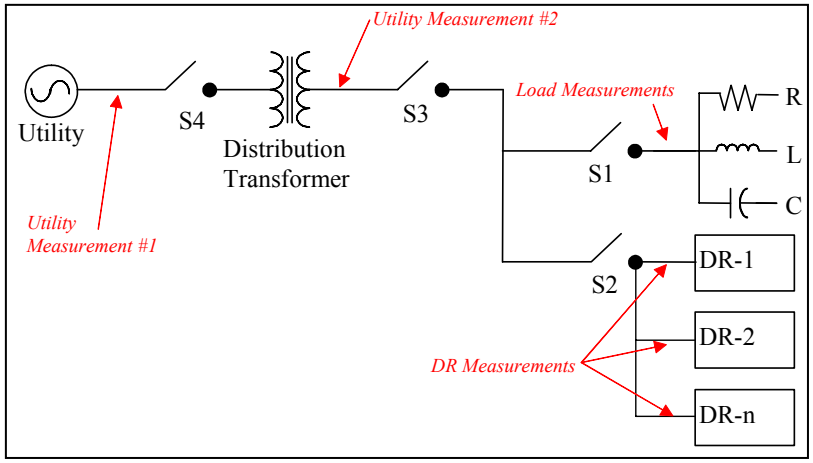
# Interconnection Success




| Savings Through New Rule 2001 - 2003 | |
|---|---|
| < 1MW | > 1MW |
| $ 8 Million | $ 18 Million |

- Resolves technical safety issues
- Establishes technology and size neutral review process
- Enables insertion of new generation into grid
- Identifies testing and certification requirements
  - 9 certified units thus far
- Dramatically reduces delay times and costs
- Next steps – network systems

# Grid Effects Testing Success

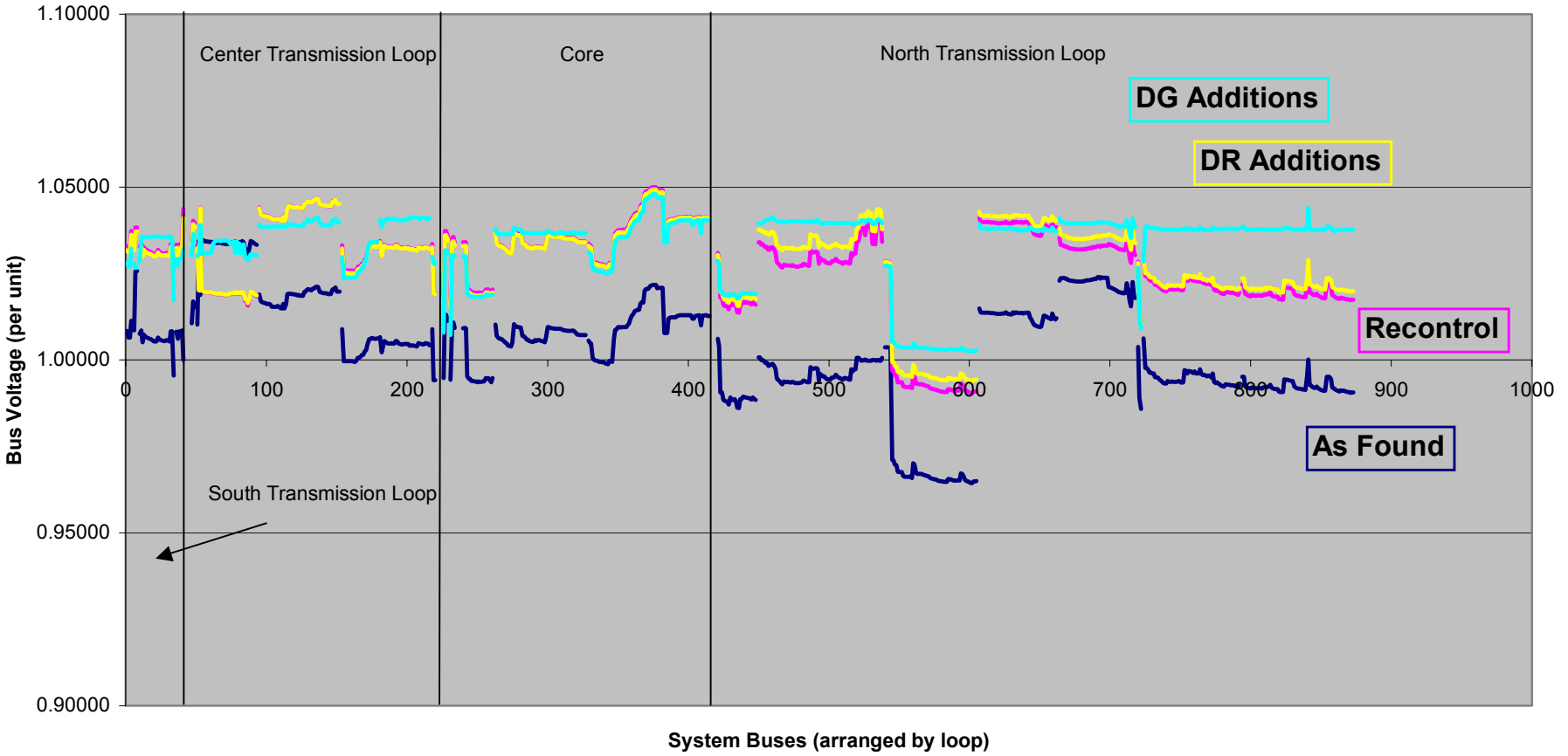

- Establishes laboratory testing facility:
  - Diverse DG technology types
  - Penetration level
  - Grid stability
  - Interoperability
- Can simulate various feeder designs
- Includes 3 test bays with complete data acquisition and control
- Results thus far:
  - In ***ideal*** laboratory conditions single units can island
  - In practice, ***extremely*** improbable
  - Findings invaluable for:
    - Major UL 1741 revisions
    - Manufacturers
- Next steps – voltage stability

# Grid Effects Modeling Success

- Objective – demonstrate a methodology to determine:
  - Whether ideally-placed DG and Demand Response (DER) can enhance performance of a power delivery system
  - Where DER should be located and operated to provide most system benefits
  - Potential system benefits of this portfolio of DER projects
  - Also, to investigate AEMPFAST system optimization software
- Subject System – Silicon Valley Power
  - City of Santa Clara, CA
  - 419 potential DR/DG sites
  - ~ 400 MW Summer 2002 Peak Load

# Grid Effects Modeling Success

**Voltage Profile with 318 Ideally-located DG Projects (3 kW - 9 MW, avg 173 kW each)**
**Actual Summer 2002 Loads and Topology**



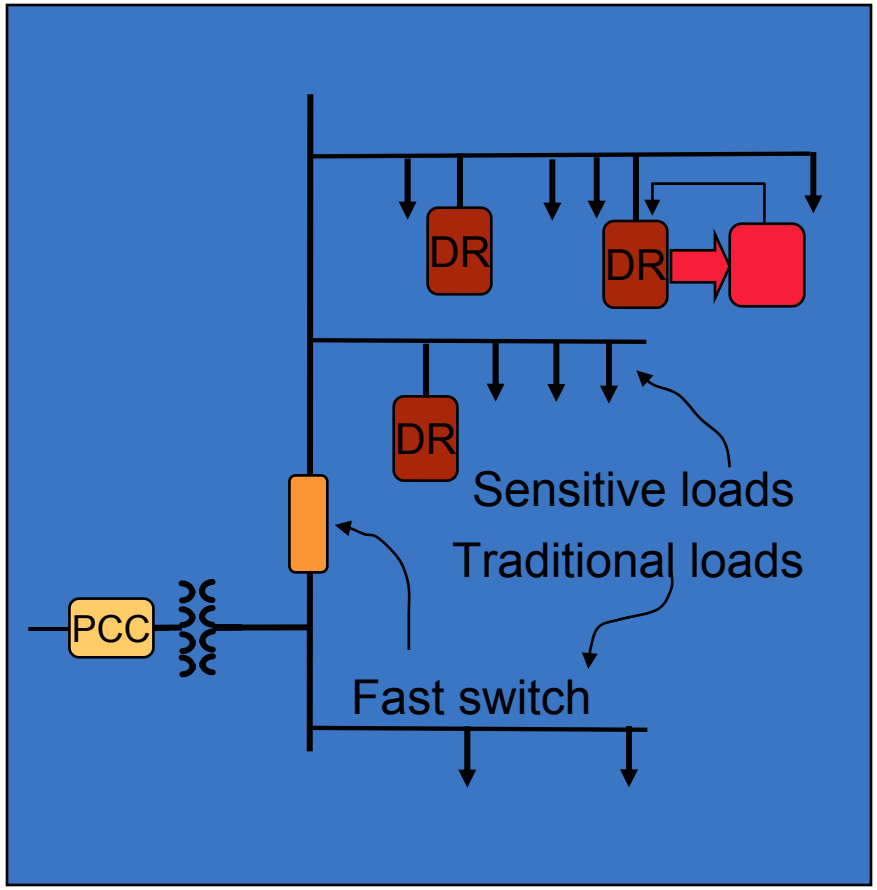
# Grid Effects Modeling Success

- System Benefits
  - Reduced MW losses and VAR consumption
  - Low- and high-voltage buses eliminated, flatter voltage profile
  - Greater operating flexibility
  - Quantifiable benefits
  - Get 80% of benefits by controlling only 20% of devices
- Approach
  - Systematic way to assess potential system benefits of DER, characterize beneficial DER projects, and determine ideal operating profiles
  - Recontrols and placement of DER additions determined using AEMPFAST software
- Next Steps
  - Large-scale utility implementation
  - Expanded set of solutions to operational problems

# Microgrid Success

THE UNIVERSITY of WISCONSIN MADISON

CERTS
CONSORTIUM FOR ELECTRIC RELIABILITY TECHNOLOGY SOLUTIONS




## Benefits of Approach

- Low cost delivery of premium power
- Enables effective use of CHP
- Single controllable unit to utility
- Smoothly move between parallel and island

## Operational Concept

- Intentional islanding
- Automatic re-synchronizing
- No fast communications needed
- Power & voltage dispatch (i.e., minutes)
- Load following
- Each source has:
  - Voltage control with droop
  - Power versus frequency droop

## Status

- Modeling and bench scale testing completed

## Next steps

- Laboratory test

# New Cost Reduction Priorities

- Increase functionality of interconnection equipment and further reduce equipment and installation costs
- Approach:
  - Continue development of a universal interconnection device with increased functionality and reliability, and reduced cost – collaborative with NREL and DOE
  - Integrate interconnection functions with power electronic interfaces to improve functionality and reliability, and reduce cost – plug and play at the systems level

# Power Electronics Interface Initiative

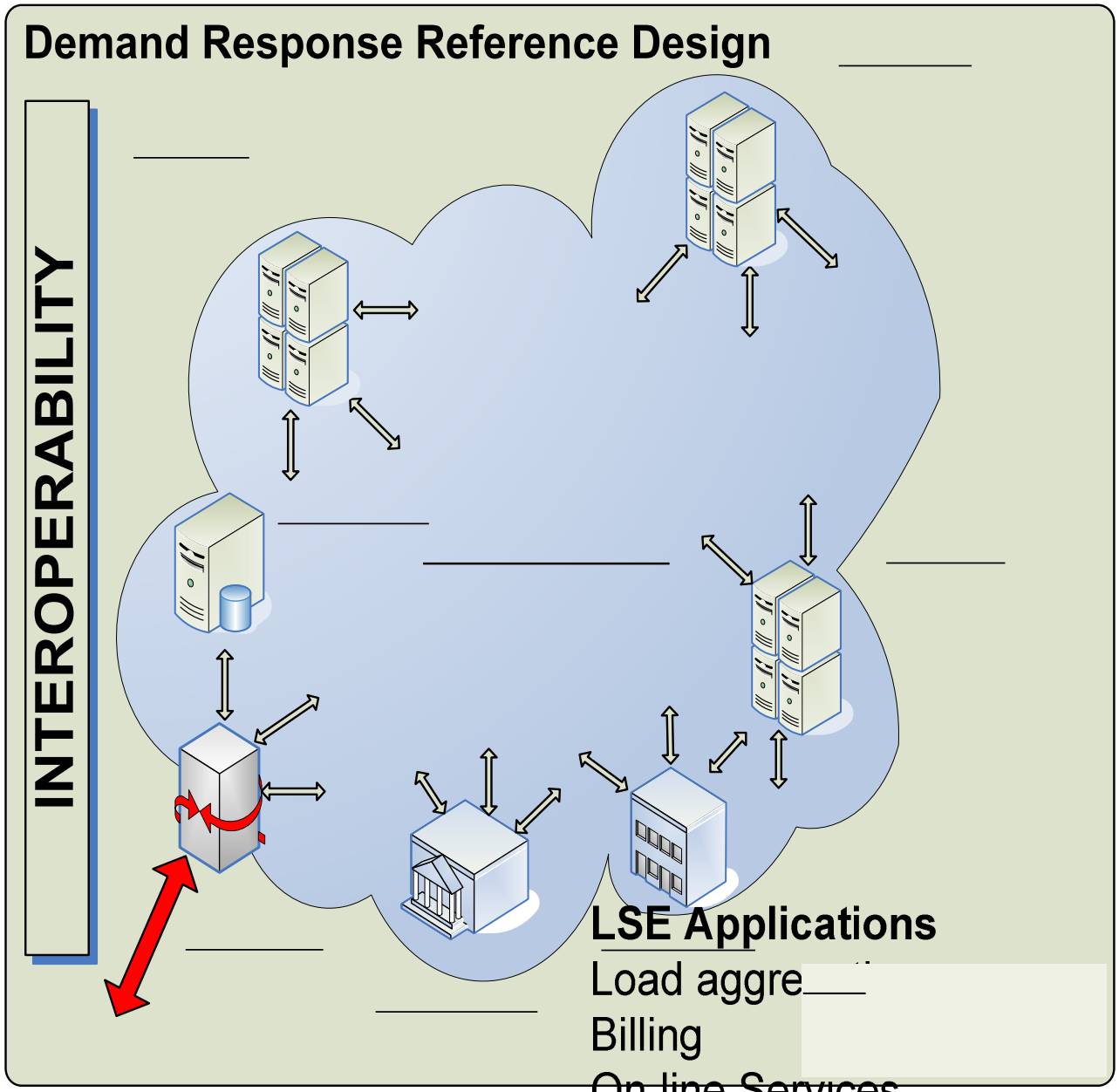
**Advanced Power Electronics Interfaces**


**Functions**

- Power Conversion
- Power Conditioning (PQ)
- Protection
- DER and Load Control
- Ancillary Services
- Monitoring and Control

- Need - to develop a modular architecture for:
  - Standardized
  - Highly integrated
  - Modularized power electronics interconnection technologies
- As close as possible to “plug-and-play”
- Goal - to develop power electronics technology that improves and accelerates the use of DER systems
- Objective - reduce costs for DER and interconnections by developing standardized, high production volume, modules

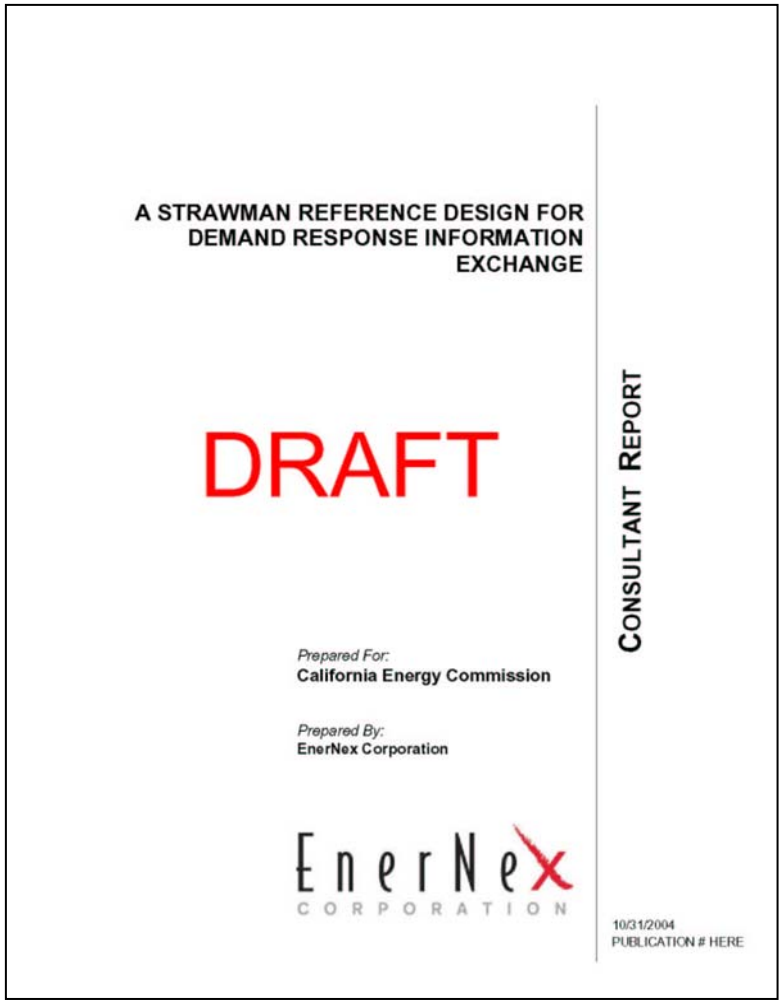
# Considering Reference Design For DER




***To allow seamless information exchange in ways we can't fully define today, there has to be a common reference design for California's demand response infrastructure.***

**Same communications infrastructure will also allow for dispatch of DG.**

# What Is A Reference Design?

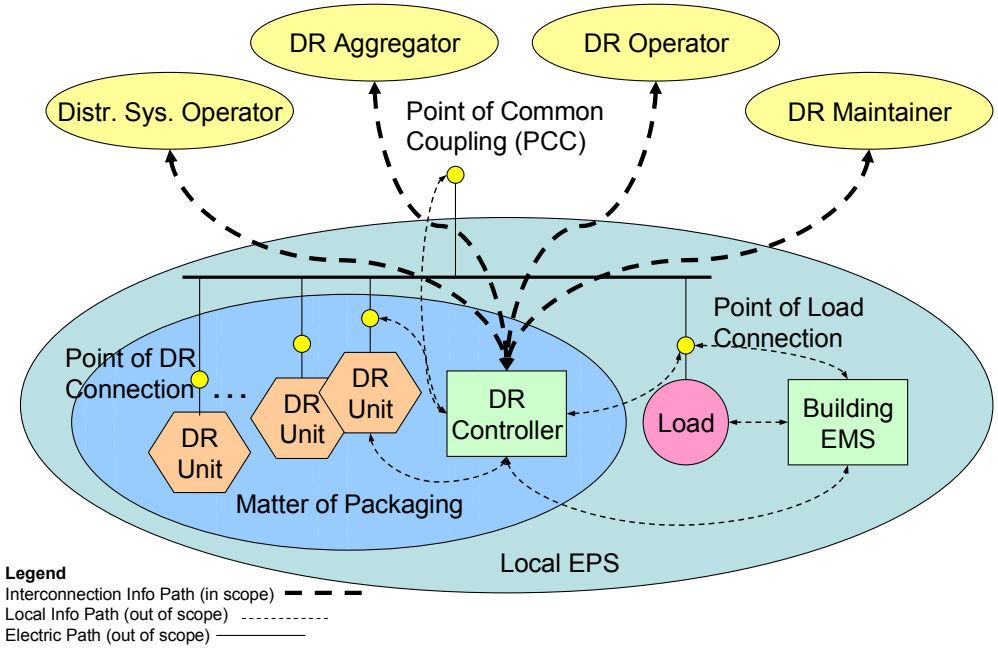



http://ciee.ucop.edu/dretd/ReferenceDesign.pdf

- A framework for:
  - Understanding significant relationships between entities within some environment (e.g., power delivery enterprise)
  - Development of consistent standards and specifications supporting that environment
- Good Example is the Cellular Telephone
  - Reference design provides for human interfaces (e.g., keyboard, display)
  - Does not specify how to implement what is behind these elements
  - Does this by defining key points of interoperability between the device and its environment
- Approach
  - Use California Energy Commission's Load Management Authority to establish a demand response infrastructure reference design

# New Communications Priorities

**Need multiple demonstrations and wide scale acceptance of open architectures for communicating and controlling DG.**

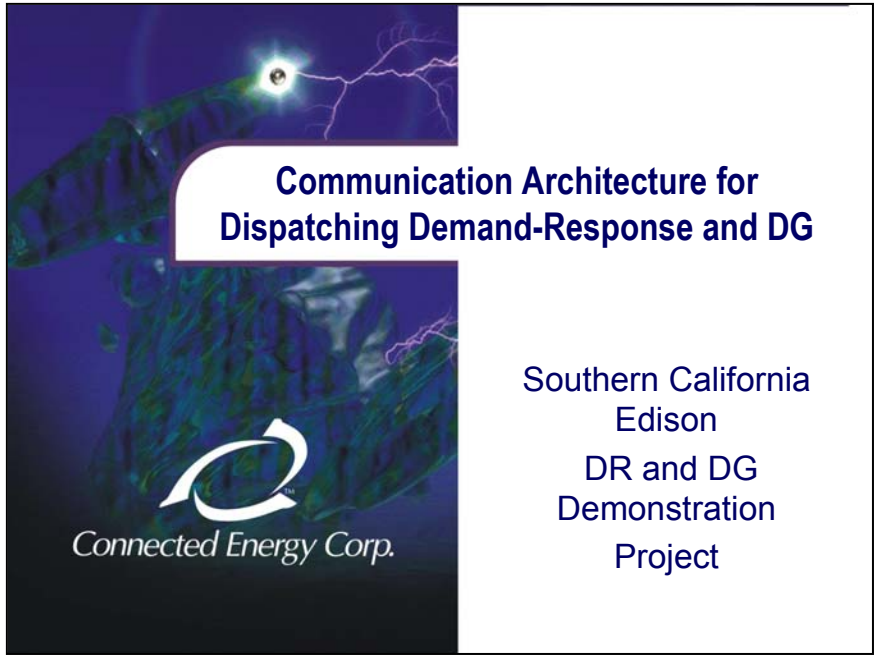



**Problem:**

- DER domain highly heterogeneous, fragmented, multi-player, legacy-driven and endlessly configurable
- Must accommodate many needs

**Solution:**

- Aggregation through seamless interoperability
- Builds on DOE's Advanced Communication and Control Program
- Builds on open architecture concept



# Closing Thoughts

**DER Integration is a growing focus area for California's R&D Programs.**

- Initial focus was on safety aspects of interconnection and utility system effects
- Recent focus has been on market integration R&D expressly to support policy activities
  - Understanding system benefits
  - Regulatory and utility incentives to unlock system benefits of DER
- Work will continue build on these important areas
- New efforts will look at cost reduction, improved reliability, interoperability in areas of power electronics and communications and control

# Contact Information

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California Energy Commission DG Website Resources

www.energy.ca.gov/distgen

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# Additional DER Resources

| Title | Topics | Website |
|---|---|---|
| Energy Commission<br>Investigation<br>04-DIST-GEN-1 | • Interconnection<br>• Distribution Planning<br>• Costs And Benefits<br>• Emerging DG Technologies | www.energy.ca.gov/distgen_oii/index.html |
| Public Utilities Commission<br>Rulemaking<br>R.04.03.017 | • Costs And Benefits<br>• Utility Planning And Procurement<br>• Interconnection<br>• Incentives<br>• Emerging DG Technologies | www.cpuc.ca.gov/proceedings/R0403017.htm |
| Energy Commission<br>DG Research Activities | • Renewable And Nonrenewable DG<br>• Utility System Impacts<br>• Integration In Markets | www.energy.ca.gov/pier/index.html |